

A New Cuttlefish, *Sepia grahami*, sp. nov. (Cephalopoda: Sepiidae) from Eastern Australia

AMANDA REID

6 Sturt Place, Bulli, NSW, 2516. Email: mandy.reid@optusnet.com.au

Reid, A. (2001). A new cuttlefish, *Sepia grahami*, sp. nov. (Cephalopoda: Sepiidae) from Eastern Australia. *Proceedings of the Linnean Society of New South Wales* **123**, 159-172.

A new cuttlefish, *Sepia grahami*, sp. nov. (Cephalopoda, Sepiidae) from eastern Australia is described. The species is found from between southeast of Yamba (29°33'S 153°25'E) to Tathra (36°40'S 150°03'E) in New South Wales at depths ranging from 2.5–84 meters. The presence of a pair of distinctive 'eyespot' on the dorsal mantle has led to its misidentification as *Sepia mestus* Gray, 1849 and because of similarities in the cuttlebone it may also be confused with the commercially important species *Sepia rozella* (Iredale, 1926). Distinguishing features are provided to enable the reliable identification of mature specimens of this new species.

Manuscript received 2 July 2001, accepted for publication 21 November 2001.

KEY WORDS: Sepiidae, *Sepia grahami*, *Sepia mestus*, *Sepia rozella*, new species, Australia.

INTRODUCTION

Australia is endowed with the richest cuttlefish fauna in the world. Of the 113 nominal species, one third occur in Australian waters. The new species described here brings the total to 37 species found in Australian waters. The species, from eastern Australia, was discovered among collections held in the Australian Museum and the Museum Victoria. It occurs sympatrically with two species with which it has been confused: *S. mestus* Gray, 1849 and *S. rozella* (Iredale, 1926), though based on the number of specimens held in museum collections and examined in fishmarkets in Sydney, it appears that this new species occurs in lower numbers than *S. mestus* and *S. rozella*.

MATERIALS AND METHODS

This work was based on museum material. All material studied is listed in the 'Material examined' section below. Institutional acronyms used are: AM, Australian Museum, Sydney, Australia; MV, Museum Victoria, Melbourne, Australia.

Measurements and indices used throughout this paper are primarily those given in Roper and Voss (1983), using dorsal mantle length (ML) as a size standard. Some additional measurements are used, and these with the definitions listed by Roper and Voss (1983) are given in Reid (2000). Parts of the club and arm sucker rims are described using the terminology of Nixon and Dilly (1977) while nomenclature for the radula follows Nixon (1995). Beaks were described following Clarke (1986). Diagrammatic illustrations of measurements and terminology used for key structures are shown in Reid (2000).

Measurements were made either using dial callipers, or an eyepiece micrometer inserted in a stereo microscope. All measurements are expressed in millimetres (mm). Measurements and counts for individual specimens and ranges of arm length indices, arm sucker diameter indices, and arm sucker counts are presented in the tables; ranges for all other characters appear in the text. In the species description and tables, the range of values for each character is expressed as: minimum–mean–maximum (standard deviation, SD). Values for each sex are given separately.

Measurements for structures that were clearly distorted or broken were not attempted, and these, in addition to missing and unknown values, appear as a dash (–) in the tables. Ranges for specific character traits given with the species description do not, therefore, always refer to the total number of specimens examined.

For examination of arm and club sucker rims, suckers were removed from the middle of designated arms and the tentacular club, mounted in glycerine jelly and viewed using a compound microscope. Radulae and beaks were dissected from the buccal mass, and soaked for approximately 30 minutes in a warm, saturated potassium hydroxide solution, then radulae were cleaned using forceps and a fine brush. Radulae were mounted in glycerol, and the new, unused portion was examined. All characters refer to both sexes unless stated otherwise.

The species description was generated using DELTA (DEscription Language for TAXonomy) software (Dallwitz 1980; Dallwitz *et al.* 1993; Partridge *et al.* 1993).

Taxonomy

Sepia grahami, sp. nov. (Figs 1–5, Tables 1–3)

Material examined

Type material: Australia: New South Wales: *Holotype:* 1♂ (43.8 mm ML), Clarence River, 29°33'S 153°25'E–29°32'S 153°25'E, 53–49 m, 30 May 1995, coll. K. J. Graham (MV F87757). *Paratypes:* 1♂ (65.5 mm ML), 1♀ (56.8 mm ML), SE of Yamba, 29°33'S 153°25'E–29°34'S 153°24'E, 51–49 m, 30 May 1995, coll. K. J. Graham (AM C306769); 2♀ (55.4, 55.7 mm ML), NE of Woolli, 29°48'S 153°27'E–29°49'S 153°26'E, 70–65 m, 18 May 1995, coll. K. J. Graham (AM C306773); 1♂ (49.3 mm ML), 1♀ (47.4 mm ML), off Woolli, 29°49'S 153°27'E–29°48'S 153°26'E, 69–22 m, 18 May 1995, coll. K. J. Graham (AM C306389).

Other material examined: New South Wales: 1♂ (55.0 mm ML), 1♀ (49.7 mm ML), Clarence River, 29°33'S 153°29'E–29°32'S 153°29'E, 61–56 m, 26 Jun 1995, coll. K. Graham, NSW Fisheries (MV F88564); 1♂ (30.3 mm ML), 1♀ (48.9 mm ML), Clarence River, 29°38'S 153°24'E–29°39'S 153°23'E, 48–44 m, 11 Apr 1996, coll. K. Graham, NSW Fisheries (MV F88565); 1♂ (30.9 mm ML), 1♀ (35.8 mm ML), off Newcastle, 32°45'S 152°15'E–32°44'S 152°15'E, 84–82 m, 10 Oct 1995, coll. K. J. Graham (MV F87758); 3♂ (44.1–56.7 mm ML), 1♀ (53.3 mm ML), Sydney Harbour, Parsley Bay, 33°51'S 151°16'E, 4.0–2.5 m, 8 May 1976, coll. J. Paxton, D. Hoese, B. Russell and D. Blake (AM C204479); 2♀ (55.4, 80.7 mm ML), Jervis Bay, approx. 35°0'S 150°45'E, 22–23 May 1971, (AM C152595); 1♂ (45.4 mm ML), 1♀ (60.4 mm ML), off Tathra, 36°36'S 150°1'E–36°44'S 150°5'E, 59–37 m, 7 Mar 1994, coll. K. J. Graham on FRV 'Kapala' (AM C304884); 2♀ (57.6, 81.6 mm ML), off Tathra, 36°40'S 150°3'E–36°43'S 150°2'E, 48–46 m, May 1994, coll. K. J. Graham (AM C304890).

Diagnosis

Male and female arms subequal in length. Arm suckers tetraserial. Hectocotylus absent. Tentacular club with 4–5 suckers in transverse rows (usually four, rarely five);

Figure 1. *Sepia grahmi*, sp. nov.: (a) funnel organ, female 35.8 mm ML (MV F87758), scale bar 2 mm; (b) funnel locking (left) and mantle locking (right) cartilage, male 56.7 mm ML (AM C204479), scale bar 2 mm; (c) sucker rim arm 2, portion of toothed half, paratype male, 65.5 mm ML (AM C306769), scale bar 0.05 mm; (d) sucker rim, portion of non-toothed half, specimen as in (c); (e) club, paratype female, 55.7 mm ML (AM C306773), scale bar 2.0 mm; (f) club sucker rim, portion of toothed half, paratype female, 56.8 mm ML (AM C306769), scale bar 0.04 mm; (g) club sucker rim portion of non-toothed half, specimen as in (f).

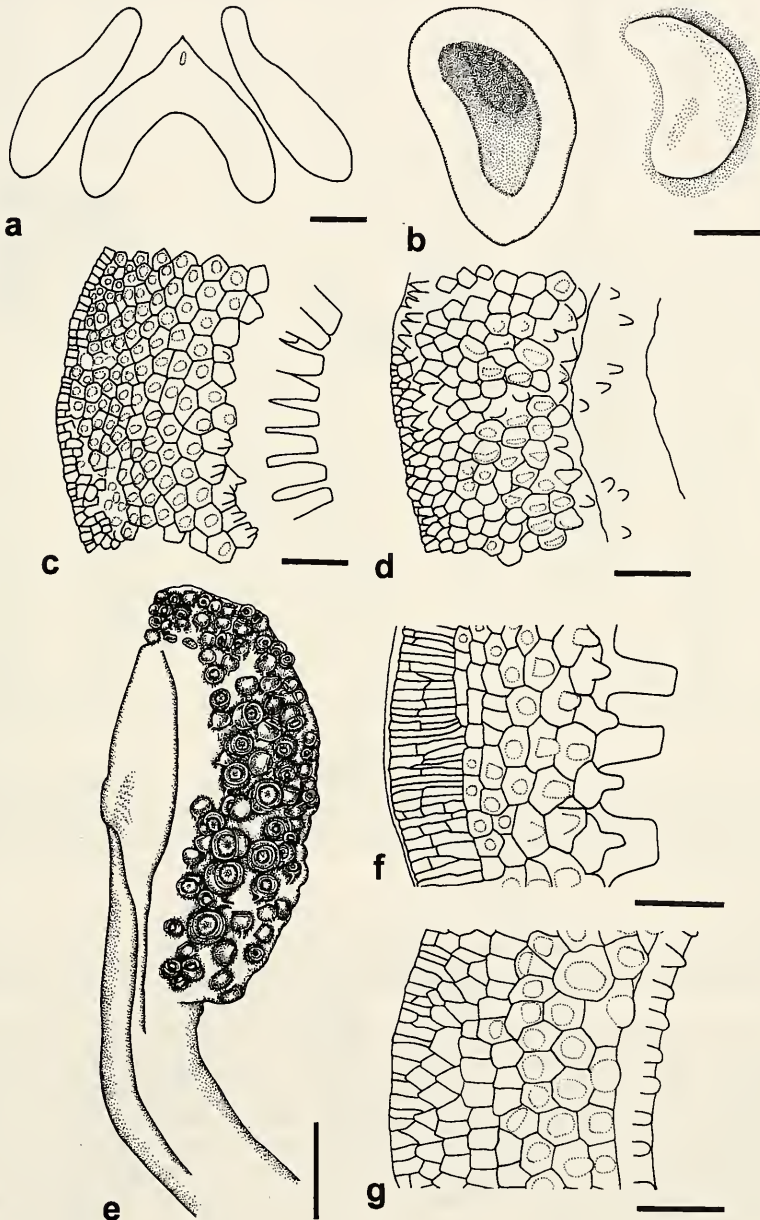


TABLE 1
Measurements (mm), counts and indices of seven male *Sepia grahami*, sp. nov.

Museum Reg. no.	MV F87757 holotype	AM C204479	AM C204479	AM C304884	AM C306389 paratype	AM C204479	AM C306769 paratype
ML	43.8	44.1	45.3	45.4	49.3	56.7	65.5
MWI	71.0	47.6	60.7	50.9	62.1	58.0	58.8
AMHI	13.7	9.5	8.6	12.6	–	12.3	8.7
VML1	90.4	87.5	88.5	86.6	84.2	90.3	100.9
FWI	8.0	11.3	8.4	14.5	11.2	13.2	15.7
FIIa	7.5	6.1	6.4	4.0	6.1	4.4	9.6
FIIp	5.0	6.1	5.7	4.0	5.5	4.6	3.1
FuL1	38.8	37.9	37.5	33.0	34.5	31.7	39.2
FFuL	16.0	15.9	17.7	13.2	18.3	17.6	21.4
HLI	39.5	31.7	31.3	37.7	41.6	33.2	42.0
HWI	55.3	46.7	43.3	45.8	51.1	41.4	42.1
EDI	15.3	12.0	13.7	15.4	15.2	12.2	12.8
AL11	43.4	38.5	35.3	37.4	48.7	38.8	55.0
AL12	41.1	36.3	35.3	37.4	46.7	35.3	53.4
AL13	42.2	35.1	37.5	39.6	53.8	34.4	45.8
AL14	52.5	39.7	39.7	39.6	46.7	40.6	67.2
ASIn1	1.37	1.36	1.32	1.32	1.32	1.23	1.30
ASIn2	1.37	1.36	1.32	1.32	1.42	1.41	1.37
ASIn3	1.37	1.36	1.32	1.32	1.52	1.41	1.37
ASIn4	1.60	1.59	1.55	1.43	1.42	1.41	1.53
ASC1	120	124	104	110	118	126	125
ASC2	110	116	110	116	134	126	130
ASC3	122	130	118	130	147	132	152
ASC4	147	152	152	160	154	176	166
CIL1	12.3	13.6	11.7	13.2	15.0	12.7	14.4
CIRC	4	4	4	5	4	5	4
TrRC	20	14	17	20	19	15	18
CISI	0.91	1.13	0.88	1.10	1.22	1.06	1.37
CISId	0.57	0.79	0.55	0.70	0.81	0.53	0.76
CISlv	0.46	0.68	0.44	0.66	0.61	0.71	0.61
GiLC	–	24	23	26	–	26	25
GiLi	28.3	30.8	33.3	25.3	31.8	28.2	31.6
SpL1	11.2	–	7.7	10.1	–	6.0	9.5
SpWI	6.12	–	4.29	6.52	–	4.41	4.84
CbL	44.4	43.4	44.7	45.2	56.6	56.8	72.6
CbWI	42.3	–	–	41.8	39.9	40.8	39.5
CbBI	10.8	–	–	10.8	10.4	10.9	11.4
SLI	5.6	–	–	6.6	5.1	6.2	6.5
StZI	56.3	–	–	57.3	61.0	60.0	62.0
LoLI	35.1	–	–	33.0	22.8	34.5	30.7
LoL/StZ (%)	62.4	–	–	57.5	37.4	57.5	49.6

suckers differ only slightly in size, 3–4 suckers slightly enlarged. Cuttlebone spine with ventral keel; sulcus shallow, narrow, indistinct; anterior striae inverted U-shaped; inner cone limbs raised to form rounded ledge posteriorly, thickened, yellowish or ochre-coloured. Mantle with dorsal ‘eyespot’.

Description

Counts and indices for individual specimens are given in Tables 1 and 2; ranges for arm length indices, arm sucker diameter indices and arm sucker counts are shown in Table 3.

Small to moderate-sized species; ML males 43.8–50.0–65.5 (SD, 8.2), females 47.4–61.0–81.6 (SD, 12.0). Mantle oval; MWI males 47.6–58.4–71.0 (SD, 7.6), females 56.3–63.5–79.9 (SD, 7.2); dorsal anterior margin triangular, obtuse; mantle extending anteriorly to level of middle of eyes (approximately); AMHI males 8.6–10.9–13.7 (SD, 2.2), females 9.6–12.4–14.4 (SD, 1.8). Ventral mantle margin emarginate, without distinct lateral angle; VML1 males 84.2–89.8–100.9 (SD, 5.4), females 86.0–88.0–90.7 (SD, 1.5). Fins wide; FWI males 8.0–11.8–15.7 (SD, 2.9), females 8.4–12.3–15.1 (SD, 2.5); anterior origin posterior to mantle margin; FIIa males 4.0–6.3–9.6 (SD, 1.9), females 3.2–6.2–11.4 (SD, 2.8); fins rounded posteriorly; narrow gap between fins; FIIp males 3.1–4.9–6.1 (SD, 1.1), females 4.3–6.6–8.8 (SD, 1.4). Funnel short, robust, broad; extends to

Figure 2. *Sepia grahami*, sp. nov.: (a) upper beak, lateral view, female 47.4 mm ML (AM C306389), scale bar 2 mm; (b) lower beak antero-lateral view, specimen as in (a); (c) radula, paratype female, 47.4 mm ML (AM C306389), scale bar 0.20 mm; (d) male reproductive tract (testis not shown), paratype 49.3 mm ML (MV F82464), scale bar 4 mm (AAG, appendix of accessory gland; AG, accessory gland; CC, ciliated canal; DDC, distal deferent canal; GO, genital orifice; MG, mucilaginous gland; SG, spermatophoric gland; SS, spermatophoric sac (containing spermatophores); T, testis; VD, vas deferens); (e) spermatophore, male 49.3 mm ML (AM C306389), scale bar 0.40 mm (CB, cement body; EA, ejaculatory apparatus; SR, sperm reservoir); (f) spermatophore, enlargement of cement body, specimen as in (e), scale bar 0.20 mm.

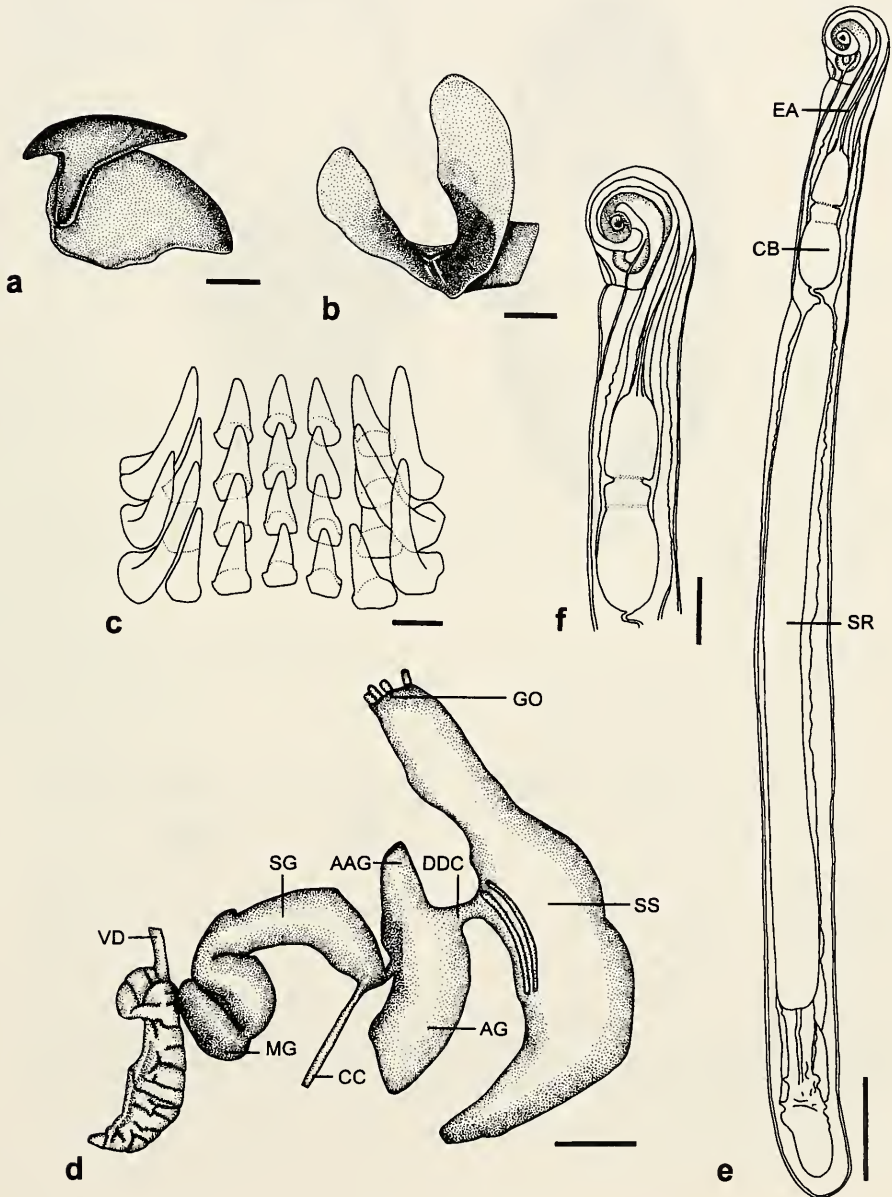


Figure 3. *Sepia grahami*, sp. nov.: (a) cuttlebone, dorsal view, female 60.4 mm ML (AM C304884), scale bar 10 mm; (b) cuttlebone, ventral view, specimen as in (a) (IC, inner cone); (c) arrangement of skin papillae dorsal and ventral to eye (E), male 56.7 mm ML (AM C204479), scale bar 16.2 mm; (d) dorsal mantle showing position of dorsal eyespots (larger posterior pair) and small granular orange spots (smaller anterior pair), female 81.6 mm ML (AM C304890), scale bar 10 mm.

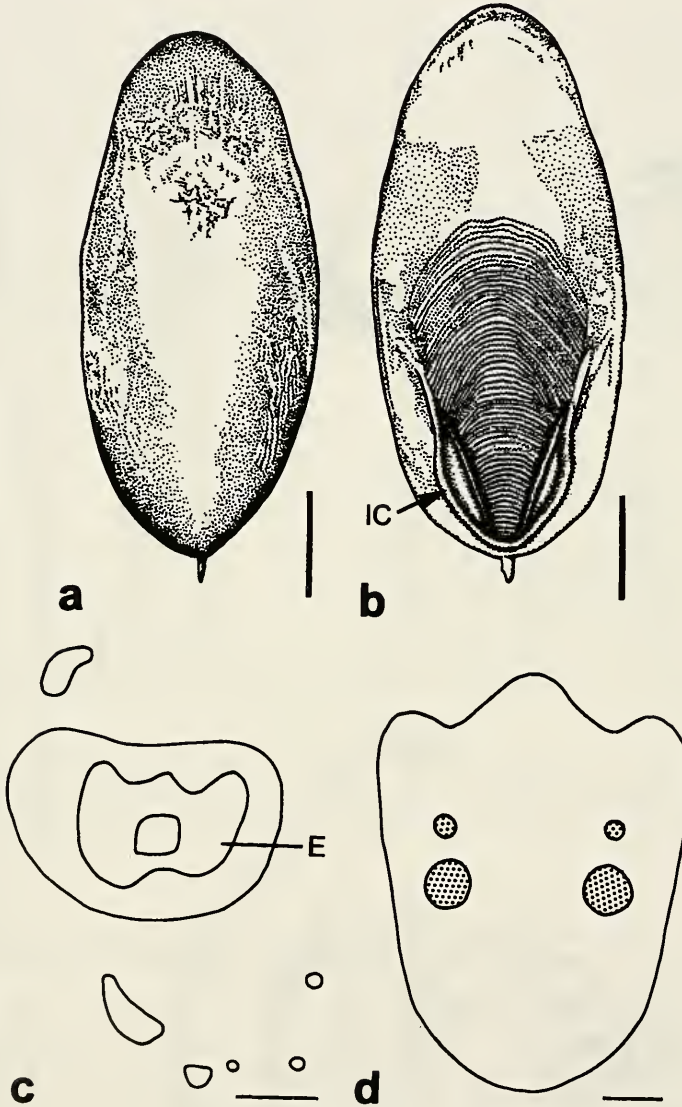


TABLE 2
Measurements (mm), counts and indices of nine female *Sepia grahami*, sp. nov.

Museum Reg. no.	AM C306389 paratype	AM C204479	AM C306773 paratype	AM C306773 paratype	AM C306773 paratype	AM C306769 paratype	AM C304890	AM C304884	AM C152595	AM C304890
ML	47.4	53.3	55.4	55.7	56.8	57.6	60.4	80.7	81.6	
MWI	56.8	56.3	61.4	63.7	62.3	79.9	58.3	66.5	66.3	
AMHI	—	9.6	13.9	—	14.4	—	12.6	11.3	12.6	
VMLI	86.9	87.4	88.4	86.0	88.9	87.2	90.7	87.4	89.5	
FWI	8.4	8.4	11.7	14.2	15.1	13.9	12.7	14.4	11.4	
FlIa	3.2	3.6	3.6	9.0	3.5	5.0	6.1	7.6	11.4	
FlIp	2.9	3.5	4.9	3.4	3.5	4.9	2.6	6.7	—	
FuI1	39.0	33.8	34.5	38.6	—	36.6	33.9	31.6	26.0	
FFuI	17.9	17.8	11.7	12.6	—	—	20.7	15.5	—	
HLI	29.5	34.7	37.0	37.0	40.0	43.6	31.8	33.2	34.6	
HWI	48.5	43.2	48.0	49.7	52.8	53.3	45.9	49.8	42.0	
EDI	11.6	11.3	12.1	12.9	16.4	10.6	12.4	11.8	10.2	
ALI1	39.0	37.5	46.9	46.0	51.1	47.7	36.4	37.2	44.1	
ALI2	40.1	37.5	46.0	57.5	47.5	43.4	36.4	39.7	41.7	
ALI3	39.0	36.6	43.3	53.9	51.1	48.6	38.1	40.9	44.1	
ALI4	39.0	37.5	42.4	59.2	54.6	59.0	44.7	43.4	51.5	
ASIn1	1.27	1.31	1.26	1.44	1.50	1.56	1.16	1.24	1.23	
ASIn2	1.27	1.31	1.26	1.62	1.58	1.56	1.16	1.24	1.23	
ASIn3	1.48	1.31	1.26	1.44	1.67	1.56	1.32	1.24	1.35	
ASIn4	1.69	1.50	1.26	1.44	1.58	1.56	1.49	1.36	1.35	
ASC1	114	135	130	116	130	110	128	136	144	
ASC2	126	136	142	144	140	140	140	146	140	
ASC3	134	150	151	134	142	142	155	146	184	
ASC4	186	176	181	176	176	180	184	184	179	
CIL1	14.1	13.1	13.0	14.9	13.7	16.7	13.1	11.9	11.6	
CIRC	4	5	4	4	4	4	4	4	4	
TRC	18	17	17	18	22	20	17	19	17	
CIS1	1.05	1.03	1.08	1.08	1.06	1.39	1.08	1.12	1.23	
CISId	0.53	0.66	0.63	0.72	0.70	0.69	0.50	0.56	0.74	
CISV	0.42	0.56	0.54	0.54	0.62	0.52	0.50	0.50	0.67	
GiLC	—	—	—	—	—	—	26	—	—	
GiL1	—	50.7	—	33.6	—	39.4	35.6	31.0	32.5	
EgD1	—	—	—	10.2	8.8	—	—	4.5	6.7	
CbL	51.8	52.2	56.1	62.2	57.4	63.9	53.9	—	83.5	
CbW1	43.6	—	39.4	43.1	43.0	43.7	48.4	—	40.4	
CbB1	10.6	—	10.2	10.1	9.8	10.3	11.7	—	11.4	
SL1	5.2	—	5.9	5.9	—	3.8	6.5	—	—	
SIZ1	61.8	—	59.0	64.3	66.2	62.0	62.7	—	58.7	
LoL1	32.2	—	36.5	29.4	28.7	34.0	39.9	—	36.5	
LoL/SIZ (%)	52.2	—	61.9	45.8	43.4	54.8	63.6	—	62.2	

Figure 4. Cuttlebones, dorsal and ventral views. *Sepia grahami*, sp. nov., paratype AM C306769, 72.9 mm CbL: (a) dorsal view, (b) ventral view. *Sepia mestus* Gray, AM C152722, 80.5 mm CbL: (c) dorsal view, (d) ventral view. *Sepia rozella* (Iredale), MV, 113.7 mm CbL: (e) dorsal view, (f) ventral view. Scale bars 1 cm.

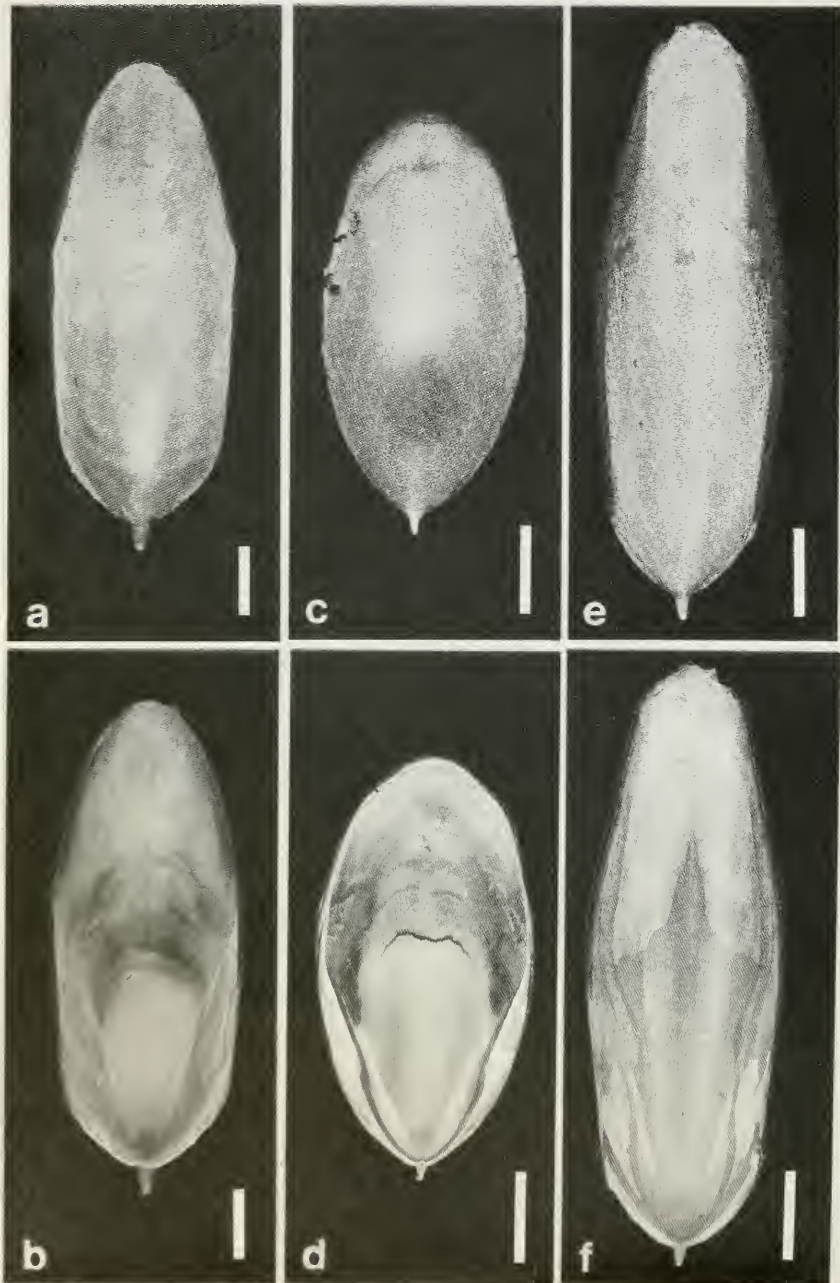


Figure 5. Distribution of *Sepia grahami*, sp. nov. (large circles); arrow indicates the type locality.

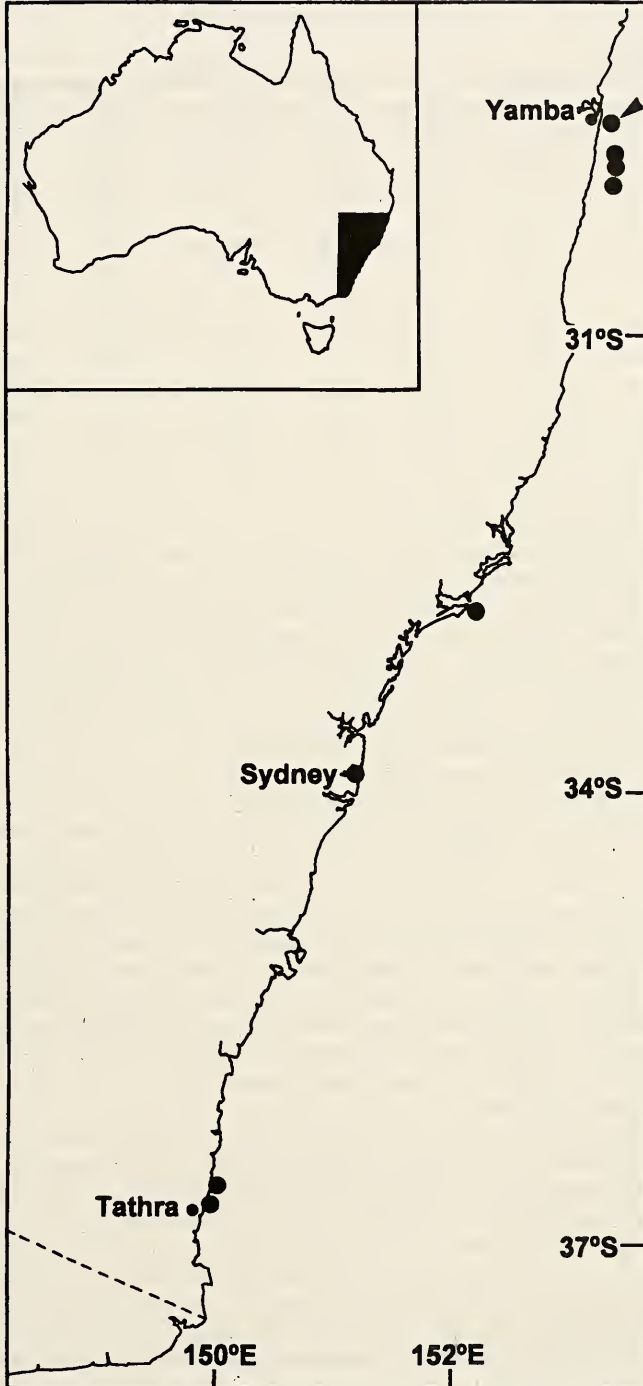


TABLE 3

Sepia grahami, sp. nov.; ranges of arm length indices (ALI), arm sucker diameter indices (ASIn) and arm sucker counts (ASC) of seven mature males and nine mature females. min. = minimum, max. = maximum, SD = standard deviation.

	Males				Females			
	min.	mean	max.	SD	min.	mean	max.	SD
ALI1	35.3	<u>42.4</u>	55.0	7.1	36.4	<u>44.2</u>	57.5	7.3
ALI2	35.3	<u>40.8</u>	53.4	6.9	36.4	<u>43.3</u>	57.5	6.4
ALI3	34.4	<u>41.2</u>	53.8	6.8	36.6	<u>44.0</u>	53.9	6.1
ALI4	39.6	<u>46.6</u>	67.2	10.3	37.5	<u>47.9</u>	59.2	8.3
ASIn1	1.23	<u>1.32</u>	1.37	0.04	1.16	<u>1.33</u>	1.56	0.14
ASIn2	1.32	<u>1.37</u>	1.42	0.04	1.16	<u>1.36</u>	1.62	0.18
ASIn3	1.32	<u>1.38</u>	1.52	0.07	1.24	<u>1.40</u>	1.67	0.14
ASIn4	1.41	<u>1.50</u>	1.60	0.08	1.26	<u>1.47</u>	1.69	0.13
ASC1	104	<u>118</u>	126	8	110	<u>127</u>	144	11
ASC2	110	<u>120</u>	134	10	126	<u>139</u>	146	6
ASC3	118	<u>133</u>	152	12	134	<u>149</u>	184	15
ASC4	147	<u>158</u>	176	10	168	<u>179</u>	186	6

level of anterior rim of eye; FuLI males 31.7–36.1–39.2 (SD, 3.0), females 26.0–34.3–39.0 (SD, 4.2). Funnel free portion approximately half funnel length; FFuI males 13.2–17.1–21.4 (SD, 2.5), females 11.7–16.0–20.7 (SD, 3.4). Funnel organ dorsal elements inverted V-shaped with low medial swelling and small papilla in front; ventral elements oval with acute anterior tips (Fig. 1a). Mantle-locking cartilage curved, with semicircular ridge; funnel-locking cartilage with depression which corresponds to ridge (Fig. 1b). Head short; HLI males 31.3–36.7–42.0 (SD, 4.6), females 29.5–35.7–43.6 (SD, 4.3); head broad, narrower than mantle; HWI males 41.4–46.5–55.3 (SD, 5.1), females 42.0–48.1–53.3 (SD, 3.9). Eyes moderate size; EDI males 12.0–13.8–15.4 (SD, 1.5), females 10.2–12.1–16.4 (SD, 1.8); ventral eyelids present.

Male and female arms subequal in length. Arm length index (ALI) of longest arms in males (ALI4) 39.6–46.6–67.2 (SD, 10.3), ALI of longest arms in females (ALI4) 37.5–47.9–59.2 (SD, 8.3). Protective membranes in both sexes narrow; normal, not thickened. Distal arm tips in both sexes not markedly attenuate. Arm suckers tetraserial in both sexes. Suckers in males normal in size (not greatly enlarged); similar to females arm suckers in size. Chitinous rims of arm suckers with elongate rectangular teeth on distal half of inner ring (Fig. 1c), teeth absent on proximal half of ring (Fig. 1d); infundibulum with 8–9 rows of hexagonal processes, inner 4–5 (variable) rows with elongate rounded pegs, pegs becoming smaller towards periphery of sucker; peripheral sucker rim processes radially arranged, elongate, without pegs. Sucker counts range from 104–186; females with higher average counts than males.

Hectocotylus absent.

Tentacular club similar length in males and females; CILI males 11.7–13.3–15.0 (SD, 1.2), females 11.6–13.6–16.7 (SD, 1.5). Club slightly recurved; short; sucker-bearing face flattened (Fig. 1e). Club with 4–5 (usually four, rarely five) suckers in transverse rows, CIRC males 4–4–5 (SD, 0.5), females 4–4–5 (SD, 0.3); 14–22 suckers in longitudinal series, TrRC males 14–18–20 (SD, 2), females 17–18–22 (SD, 2). Suckers differing slightly in size, 3–4 suckers toward posterior end of club very slightly enlarged; distal tip of club without pair of enlarged suckers; CISI males 0.88–1.10–1.37 (SD, 0.17), females 1.03–1.12–1.39 (SD, 0.11); dorsal and ventral marginal longitudinal series of suckers differing slightly in size; dorsal marginal longitudinal series of suckers slightly larger than those in ventral marginal series; CISId males 0.53–0.67–0.81 (SD, 0.12),

females 0.50–0.64–0.74 (SD, 0.09); CISIv males 0.44–0.59–0.71 (SD, 0.11), females 0.42–0.54–0.67 (SD, 0.07). Sucker dentition: half inner ring circumference in both sexes with elongate rectangular teeth (Fig. 1f), remaining half with blunt projections (Fig. 1g); infundibulum with seven rows of hexagonal processes, innermost with elongate rounded pegs, pegs smaller towards periphery of sucker; at periphery, processes smaller, elongate-rectangular, without pegs (similar to arm suckers). Swimming keel of club extends well beyond carpus. Dorsal and ventral protective membranes not fused at base of club; joined to stalk; dorsal and ventral membranes differing in length, dorsal membrane extends beyond carpus along stalk, ventral membrane terminates at posterior end of carpus; approximately equal width; dorsal membrane forms shallow cleft at junction with stalk (Fig. 1e).

Gills with 23–26 lamellae per demibranch; GiLC males 23–25–26 (SD, 1.3), females 26. Gill length: GiLI males 25.3–29.9–33.3 (SD, 2.8), females 31.0–37.1–50.7 (SD, 7.2).

Buccal membrane without suckers. Upper beak (Fig. 2a) rostrum sharply pointed, short, length approximately equal to width, cutting edge slightly curved; hood high above crest posteriorly; crest curved, lateral wall shallowly indented posteriorly; wings and hood narrow and short; jaw angle slightly less than 90 degrees, slightly acute; hood and crest dark brown. Lower beak (Fig. 2b), rostrum protrudes only slightly, cutting edge straight; hood low on crest; crest straight, no indentation on lateral wall edge; lateral wall edge angled posteriorly, not perpendicular to crest; hood and wings, width broad; hood notch deep, broad; wings widely spaced; crest narrow; rostrum pigmented dark brown, wings dark brown on inner margin only, rest of wing light brown, crest dark brown. Radula (Fig. 2c) homodont; rhachidian teeth with truncate bases, slender, triangular, sides straight; first lateral teeth similar length and width to rhachidian teeth, asymmetrical with mesocone slightly displaced toward centre of radula; second laterals longer than first, distinctly curved on lateral margin, with broad heels; marginal teeth elongate with long tapered and curved mesocone. Digestive tract: (not illustrated) paired salivary glands approximately one-third length of buccal mass; paired digestive glands large, located close together, with narrow, elongate triangular lobes posteriorly, ducts connect digestive glands near midline with caecum, ducts with branched attached pancreatic tissue; oesophagus runs dorsally along median junction of digestive glands, joins sac-like stomach immediately posterior to digestive glands; caecum disc-like, grooved in a blunt V-shape anteriorly, surface lining finely pleated; intestine undifferentiated; ink sac very large, elongate; anal flaps well-developed.

Male reproductive tract (Fig. 2d): testis on left posterior side of visceropericardial coelom; at distal end, convoluted vas deferens opens into broad, cone-shaped mucilaginous gland, then narrower, curved, spermatophoric gland. Close to junction with lobe-shaped accessory gland and gland appendix, delicate ciliated canal joins spermatophoric gland; distal deferent canal connects appendix of accessory gland to spermatophore storage sac; genital orifice opens dorsal to left gill in anterior end of mantle cavity. Spermatophores (Fig. 2e, f): cement body bipartite; aboral end cylindrical, rounded posteriorly, connects to sperm reservoir via narrow duct; oral end of cement body cylindrical, approximately three-quarters length of, and very slightly narrower than aboral end, connects to aboral end via short neck; middle tunic commences along aboral part of cement body; ejaculatory apparatus coiled, extends into oral dilation of spermatophore. Spermatophores 3.4–4.5–6.2 mm long (SD, 1.1), 0.2–0.2–0.3 mm wide (SD, 0.1); SpLI 6.0–8.9–11.2 (SD, 2.1); SpWI 4.3–5.2–6.5 (SD, 1.0). Smallest male with well-developed spermatophores in spermatophoric sac 43.8 mm ML.

Female reproductive tract: (not illustrated) ovary hangs from dorsal wall of posterior visceropericardial coelom. Oviduct thin-walled, continuous with body cavity; distally with thickened, glandular walls (oviducal glands). Nidamental glands in mature animals occupy large portion of ventral side of mantle cavity. Accessory nidamental glands

anterior to nidamental glands. Eggs spherical, 3.6–4.9–5.7 mm diameter (SD, 0.95); EgDI 4.5–7.6–10.2 (SD, 2.5). Smallest female with well-developed eggs in ovaries 55.7 mm ML.

Subdermal cartilaginous layer between cuttlebone and skin absent. Cuttlebone (Figs 3a, b and 4a, b) length approximately equal to mantle length; outline oval; CbL males 43.4–52.0–72.6 (SD, 10.8), females 51.8–60.1–83.5 (SD, 10.4); CbWI males 39.5–40.9–42.3 (SD, 1.2), females 39.4–43.1–48.4 (SD, 2.9); cuttlebone not strongly convex in lateral view; CbBI males 10.4–10.9–11.4 (SD, 0.4), females 9.8–10.6–11.7 (SD, 0.7). Bone bluntly rounded anteriorly; bluntly rounded posteriorly; not strongly recurved ventrally. Dorsal surface creamy white (very slight pinkish tinge); evenly convex; entire surface calcified with reticulate granulose sculpture concentrated postero-laterally and posteriorly in irregular longitudinal ridges (Figs 3a and 4a); posterior end of bone not covered with smooth glaze-like substance. Dorsal median rib absent; lateral ribs present, indistinct. Chitin surrounds rim of cuttlebone outer cone. Spine present, short; SLI males 5.1–6.0–6.6 (SD, 0.6), females 3.8–5.5–6.5 (SD, 1.1); spine straight, directed dorsally; with ventral keel; fine, radiating ribs between outer cone and spine; ventral notch at base of spine absent. Dorso-posterior end of cuttlebone without median longitudinal ridge anterior to spine. Striated zone concave; StZI males 56.3–59.3–62.0 (SD, 2.4), females 58.7–62.1–66.2 (SD, 2.7); striated zone extends laterally to inner cone, not separated from outer cone by smooth marginal zones. Last locus flat; LoLI males 22.8–31.2–35.1 (SD, 5.0), females 28.7–33.9–39.9 (SD, 4.1); last locus at midline half length of striated zone, LoL/StZ(%) males 37.4–52.9–62.4 (SD, 9.8), females 43.4–54.8–63.6 (SD, 8.2); locus extends posteriorly as very narrow margin on each side of striated zone for about half its length. Sulcus extends entire length of cuttlebone; shallow, narrow (very indistinct); not flanked by rounded ribs. Last locus with shallow median indentation, not very pronounced. Anterior striae inverted U-shaped. Limbs of inner cone extend anteriorly to approximately two-thirds length of striated zone; inner cone lateral limbs not separated from outer cone by two distinct smooth zones. Inner cone limbs narrow, strap-like anteriorly, broaden posteriorly; raised to form rounded ledge posteriorly (Figs 3b and 4b); thickened (yellowish, or ochre-coloured); without calcareous ribs radiating into outer cone. Outer cone calcified; narrow anteriorly, broadens posteriorly; lateral limbs flared ventro-laterally; limbs forming thin rim ventral to spine.

Body papillae present (not visible all specimens); dorsal mantle with longitudinal row of up to six ridges along each side, close to fins; ventral mantle with longitudinal row of approximately six ridges along each side close to fins and scattered papillae ventral to these. Head papillae present; positioned dorsally and laterally; prominent ear-shaped lobe ventral to eye; second large lobe dorsal to eye; small papillae posterior to large ventral lobe (Fig. 3c). Additional small papillae scattered over head. Arm papillae present, same as those on head.

Colour (alcohol preserved specimens): head, arms, and dorsal mantle pale buff pinkish-brown (see Remarks); paired dark-brown dorsal eye spots present and pair of distinct orange spots anterior to these (Fig. 3d). Fins pale; without markings at base. Ventral pigment very pale with few evenly scattered chromatophores. Ridges orange-pink in colour.

Type locality

Australia: New South Wales, 29°33'S 153°25'E–29°32'S 153°25'E.

Distribution

Australia: New South Wales, from south-east of Yamba 29°32'S 153°25'E–off Tathra 36°44'S 150°5'E (Fig. 5); depth range 2.5–84 m.

Etymology

This species is named in honour of Ken Graham from NSW Fisheries. Ken has made an enormous contribution to our understanding of the diversity of cephalopods in eastern Australian waters through his collection of specimens and lodgement of this material in Australian museums. Ken collected almost all specimens of this new species.

Remarks

A single large male specimen (AM C306769, 66.5 mm ML) is patterned dorsally with fine transverse bars over the dorsal mantle. Though faint, the pattern is of the 'zebra'-type, typical to that seen during courtship displays in a number of male sepiids (Hanlon and Messenger 1996).

Preserved specimens of *S. grahami* have been misidentified as *S. mestus*. This is largely due to the presence of the dark dorsal 'eyespots', which are present in both species. This may also lead live *S. mestus* to be confused with *S. grahami*. The body is pinkish-brown in preserved *S. grahami* specimens, and dark purple in *S. mestus*. *Sepia mestus* is known commonly as 'the red cuttle' because the live animals are often deep reddish in colour. It may be that live *S. grahami* are paler than *S. mestus*, but until an accurate identification of a live specimen it made, this remains to be seen.

The cuttlebone is narrower in *S. grahami*, than *S. mestus* (Fig. 4a–d). The cuttlebone widths of ten mature male and ten female *S. mestus* have been measured and found to be: CbWI males 43.0–~~46.6~~–50.2 (SD, 5.1), females 48.5–~~51.1~~–52.5 (SD, 1.3). While there is some overlap in the measurements shown above for *S. grahami*, this comparison may assist in identification. The cuttlebone of *S. mestus* does not have a thickened, raised and yellowish-ochre inner cone as seen in *S. grahami*. In addition, the club has 5–6 suckers in each transverse row, while there are usually only four, and rarely five suckers in transverse rows in *S. grahami*. The arms are relatively longer in *S. grahami* than in *S. mestus* (measurements for *S. grahami* shown in italics): males ALI1 >35.3 v. <35.0, ALI2 >39.6 v. <37.6; females ALI1 >36.4 v. <34.4, ALI2 >36.4 v. <34.9, ALI3 >36.6 v. <34.9, ALI4 >37.5 v. <37.1. Finally, *S. grahami* has a greater number of suckers on the ventral arm pairs than does *S. mestus*. This is most obvious on arms 4: males ASC4 >147 v. <112; females ASC4 >186 v. <149. (Values for *S. mestus* from Reid, unpublished data.)

The cuttlebone of *S. grahami* shares some similarities with that of *S. rozella*, however, the inner cone is distinctly pink and the sulcus very deep in mature *S. rozella* (compare Fig. 4a, b with Fig. 4e, f), while the inner cone is yellowish, or ochre-coloured in *S. grahami*. Juvenies of the two species are very difficult to identify because the sulcus is not well developed in small *S. rozella* specimens. The dorsal surface of the cuttlebone (with the exception of the outer cone) is usually pinkish in *S. rozella*, while it is white in small *S. grahami* specimens. No other differences between juvenies of the two species have been found.

ACKNOWLEDGMENTS

I wish to thank Ian Loch for the loan of specimens from the Australian Museum and Dermot Henry and Melanie Mackenzie for access to facilities at the Museum Victoria.

REFERENCES

- Clarke, M.R. (1986). 'Handbook for the Identification of Cephalopod Beaks'. (Oxford Science Publications: New York).
- Dallwitz, M.J. (1980). A general system for coding taxonomic descriptions. *Taxon* **29**, 41–46.
- Dallwitz, M.J., Paine T.A. and Zurcher, E.J. (1993). 'User's Guide to the DELTA System: a General System for Processing Taxonomic Descriptions'. (CSIRO Division of Entomology: Canberra).
- Gray, J.E. (1849). 'Catalogue of the mollusca in the collection of the British Museum. Part I. Cephalopoda Antepedia'. (British Museum: London).
- Hanlon, R.T. and Messenger, J.B. (1996). 'Cephalopod Behaviour'. (Cambridge University Press: Cambridge, UK).
- Iredale, T. (1926). The cuttle-fish "bones" of the Sydney beaches. (Phylum Mollusca" Class Cephalopoda).—*Australian Zoologist* **4**, 186–196.
- Lu, C.C. (1988). A synopsis of Sepiidae in Australian waters (Cephalopoda: Sepioidea). In 'Systematics and Biogeography of Cephalopods' (Eds N.A. Voss, M. Vecchione, R.B. Toll and M. Sweeney) pp. 159–190. *Smithsonian Contributions to Zoology*, Number 586.
- Nixon, M. (1995). A nomenclature for the radula of the Cephalopoda (Mollusca) – living and fossil. *Journal of Zoology, London*. **236**, 73–81.
- Nixon, M. and Dilly, P.N. (1977). Sucker surfaces and prey capture. In 'The Biology of Cephalopods' (Eds M. Nixon and J.B. Messenger) pp. 447–511. *Symposia. Zoological Society of London*. Vol. 38.
- Partridge, T.R., Dallwitz M.J. and Watson, L. (1993). 'A Primer for the DELTA System'. (CSIRO Division of Entomology: Canberra).
- Reid, A.L. (2000). Australian cuttlefishes (Cephalopoda : Sepiidae): the 'doratosepion' species complex. *Invertebrate Taxonomy* **14**, 1–76.
- Roper, C.F.E. and Voss, G.L. (1983). Guidelines for taxonomic descriptions of cephalopod species. *Memoirs. National Museum Victoria* **44**, 48–63.